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THE UNIVERSITY OF TENNESSEE
DEPARTMENT OF ELECTRICAL ENGINEERING

DEVELOPMENT

OF A

HIGH FREQUENCY

STEERABLE ANTENNA

Navy Department
Bureau of Ships
Electronics Divisions

Interim Development
Report No. 11

Contract No. NObsr-57448
Index No. NE-091035 ST7
10 August 1953

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362-806

A PROJECT OF THE ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE COLLEGE OF ENGINEERING
Knoxville 16, Tennessee

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INTERIM DEVELOPMENT REPORT
FOR
DEVELOPMENT OF A HIGH FREQUENCY STEERABLE ANTENNA

This report covers the period
1 July 1953 to 31 July 1953

ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE
KNOXVILLE, TENNESSEE

Navy Department | Bureau of Ships
Electronics Divisions
Contract No. NObsr-57448 | Index No. NE-091035 ST7
10 August 1953

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ABSTRACT

This report covers work done on Contract No. NObsr-57448, Index No. NE-091035 ST5, at The University of Tennessee during the month of July 1953.

The following was accomplished:

1. The revolving antenna mount was installed at the antenna facility. This facility is now complete, with the exception of the recorder which has not yet been delivered.

2. Further work of a mathematical nature was done on the traveling wave circular antenna.

3. Vertical patterns for a inclined V antenna were calculated for several combinations of height, leg length, and angle between wires.

4. The litterature search for information concerning angle of arival has been completed, and calculations are being made using this information together with the propagation results reported previously to determine the maximum possible fields for various transmission conditions.

5. Experimental study of models of some of the more promising antenna types has been initiated.

[redacted]

PART I

Purpose

This project involves the development of a high frequency steerable antenna having the following characteristics:

1. It shall be operable throughout the frequency range of 4 to 32 megacycles per second.

2. It shall be capable of four, or more, simultaneous transmissions on different frequencies, and at different azimuth and elevation angles.

3. For each transmission, it shall be capable of being directed to any azimuth angle and to any elevation angle between the horizon and 30° above the horizon.

The communication system shall provide reliable 24-hour day-to-day communication with a 20-decibel signal-to-noise ratio. The ranges to be covered are from approximately 500 nautical miles to 4000 nautical miles.

The development consists of two phases:

Phase I. Theoretical and experimental studies.

Phase II. Development of design criteria.

General Factual Data

Personnel:

F. V. Schultz	Project Director	34 1/2	Man-hours
W. D. Leffell*	Assistant Engineer	15	Man-hours
J. D. Tillman	Assistant Engineer	8	Man-hours
W. J. Bergman	Junior Engineer	41	Man-hours
H. P. Neff	Junior Engineer	176	Man-hours
L. W. Ricketts*	Junior Engineer	141 1/2	Man-hours
G. R. Turner	Secy-Draftsman	21	Man-hours
W. H. Williams*	Technician	24	Man-hours
H. W. Knox	Student Computer	68 1/2	Man-hours
D. Marcum	Student Computer	33	Man-hours
N. Boyd	Typist	4	Man-hours
A. Rich	Multilith Operator	2	Man-hours

* Preparation of antenna test facility.

References

Bruce, E. and Beck, A. C., "Experiments with Directivity Steering for Fading Reduction," Bell System Technical Journal, Vol. 14, p. 195, April 1935.

Foster, Donald, "Radiation from Rhombic Antennas," Proceedings of the Institute of Radio Engineers, Vol. 25, p. 1327, October 1937.

Harper, A. E., Rhombic Antenna Design, D. Van Nostrand Co., Inc., New York, 1941.

Harrison, C. W., "Radiation from Vee Antennas," Proceedings of the Institute of Radio Engineers, Vol. 31, p. 362, July 1943.

Harrison, C. W., "The Radiation Field of Long Wires, with Application to Vee Antennas," Journal of Applies Physics, Vol. 14, p. 537, October 1943.

Harrison, C. W., "The Inclined Rhombic Antenna," Proceedings of the Institute of Radio Engineers, Vol. 30, p. 241, May 1942.

"Ionospheric Radio Propagation," U. S. Department of Commerce, National Bureau of Standards Circular No. 462, June 1948, Washington, D. C.

Knudsen, H. L., "The Field Radiated by a Ring Quasi-Array of an Infinite Number of Tangential or Radial Dipoles," Proceedings of the Institute of Radio Engineers, Vol. 41, p. 781, June 1953.

Kraus, J. K., Antennas, McGraw-Hill Book Co., New York, 1950, Chapter 2.

Sherman, J. B., "Circular Loop Antennas at Ultra-High Frequencies," Proceedings of the Institute of Radio Engineers, Vol. 32, p. 534, September 1944.

Williams, H. P., Antenna Theory and Design, Pitman and Sons, Ltd., London, 1950.

Detail Factual Data

1. Construction of antenna test facilities has been continued. A rotary mount has been installed, and the selsyn system for transmitting the azimuth pointing to a high speed level recorder has been connected. These items have been tested, and their performance is satisfactory. A ground plane of adequate size has been constructed for use with this mount. The test site is now essentially complete, except for the level recorder which has not yet been delivered. This recorder is expected by the end of the month. The antenna test facilities are now being used in connection with the work on Contract No. NObsr-57032, Index No. NE-091035 ST5.

2. Only a relatively small amount of work was done on the circular traveling-wave antenna because the engineer involved, W. J. Bergman, was not available for a large part of the month. Efforts were made to rearrange the complicated expression for the radiation pattern of this antenna into a form more amenable to calculation and from which it would be easier to roughly predict radiation patterns without carrying out lengthy calculations. It was found that the original form appeared to be the simplest obtainable. In an attempt to obtain a usable radiation pattern two expedients were tried. One consisted of using a conductor phase velocity different from that in free space and no improvement resulted. The other approach was to obtain an expression for the pattern of a semicircular antenna. This line of attack is being expanded into a more general study of circular arrays and their applications to the present job.

3. The study of tilted V-antennas was continued. The antenna is assumed to consist of two inclined wires suspended between the top of a supporting pole and ground, with the feed point at the top of the pole. Perfectly conducting ground is also assumed. Vertical patterns were calculated for several combinations of leg length, height above ground, and angle between wires. These patterns are shown in Figures 1 to 9, inclusive. Several reports indicate that a gain of the order of 10 decibels over a half wave dipole in free space may be expected over a 2 to 1 frequency range. This gain falls to about 8 decibels when the antenna is used over a 3 to 1 frequency range. These preliminary calculations indicate that an antenna of this type may have an application to the present task.

4. The search of the literature for information concerning angle of arrival has been completed. The information on this subject is mea-

Detail Factual Data - Continued

ger and often contradictory. However, it appears that fluctuations of the order of $\pm 3^{o}$ in bearing and $\pm 6^{o}$ in elevation are to be expected for single hop modes, while for multi-hop modes the variations are greater, and occur at a higher rate. Work is now in progress to correlate this data with the propagation data previously reported. From the information on angle of arival minimum feasible beamwidths may be assigned, and from these beamwidths an upper limit on the available gain can be calculated. This may be added to the field intensities already calculated for one kilowatt effective radiated power to give an upper limit on the possible field intensity for that communication link. These results will be reported when the calculations are complete.

5. Experimental work has recently been initiated to obtain the patterns of models of some of the more promising antennas. The effort thus far has been directed toward the construction of a feeding and matching system.

DEPARTMENT OF ELECTRICAL ENGINEERING
ENGINEERING EXPERIMENT STATION
THE UNIVERSITY OF TENNESSEE

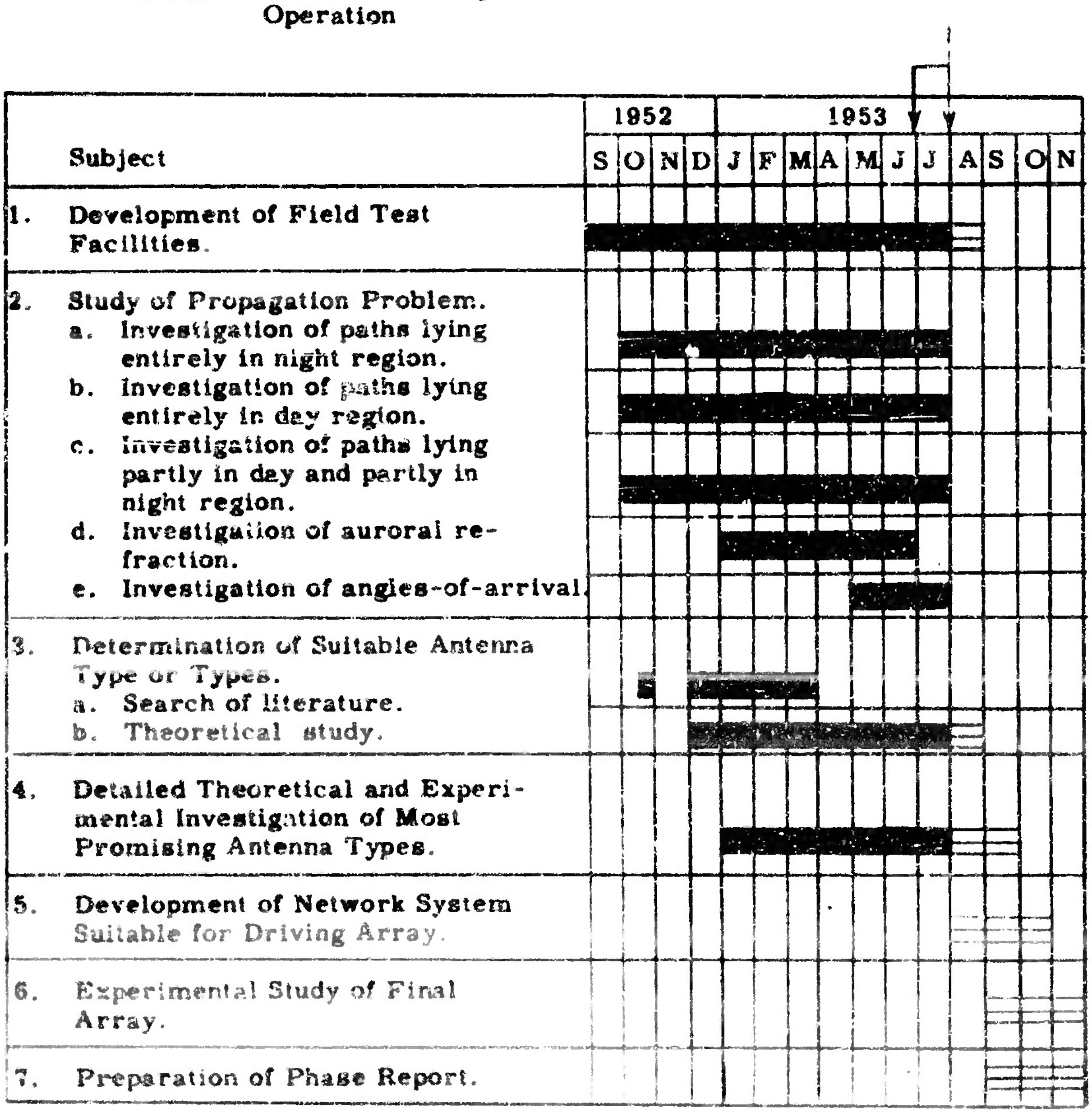
PROJECT PERFORMANCE AND SCHEDULE

Index No. NE-091035 ST7

Contract No. NObsr-57448 Date: 10 August 1953

Legend: Work Performed Period Covered: 1/7/53 to 31/7/53

Schedule of Projected Operation



Conclusions

1. No final conclusion has yet been reached concerning the circular traveling wave antenna, but the results so far obtained are not particularly promising.

2. The use of inclined radial wires to form a "Maypole" antenna seems to give patterns suitable to the present task.

3. Calculations of maximum possible field intensities for a given communication link have not progressed far enough to allow any conclusions to be drawn.

Program for Next Interval

1. The work on the circular traveling-wave antenna is being expanded into a general investigation of the application of circular antennas, or arrays, to the present job.

2. The calculation of maximum possible field intensities for a given communication link will be completed.

3. The study of the "Maypole" antenna will be continued, and additional patterns will be calculated.

4. The experimental work on a model basis will be continued.

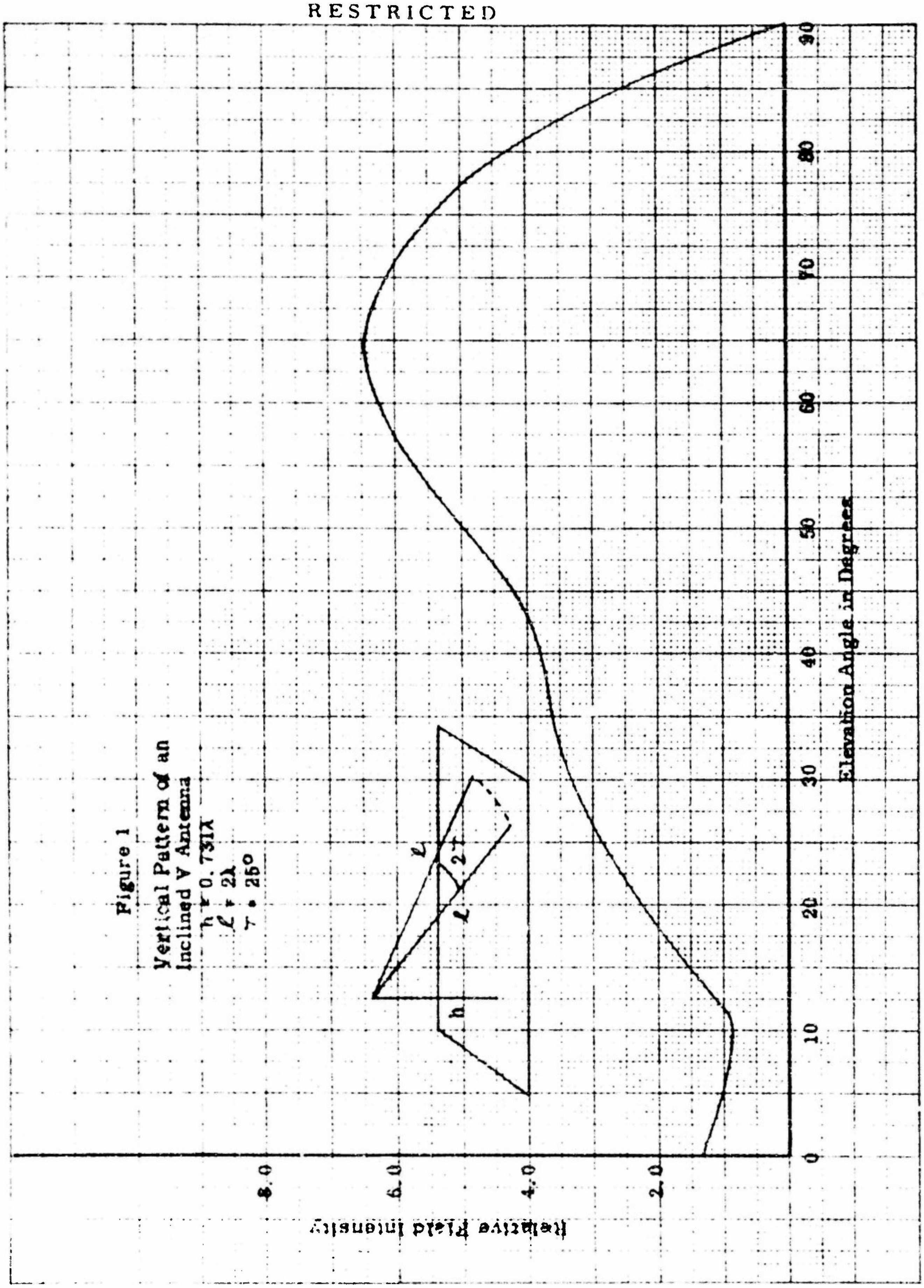


Figure 1

Vertical Pattern of an Inclined V Antenna

$h = 0.731\lambda$

$\ell = 2\lambda$

$\tau = 25°$

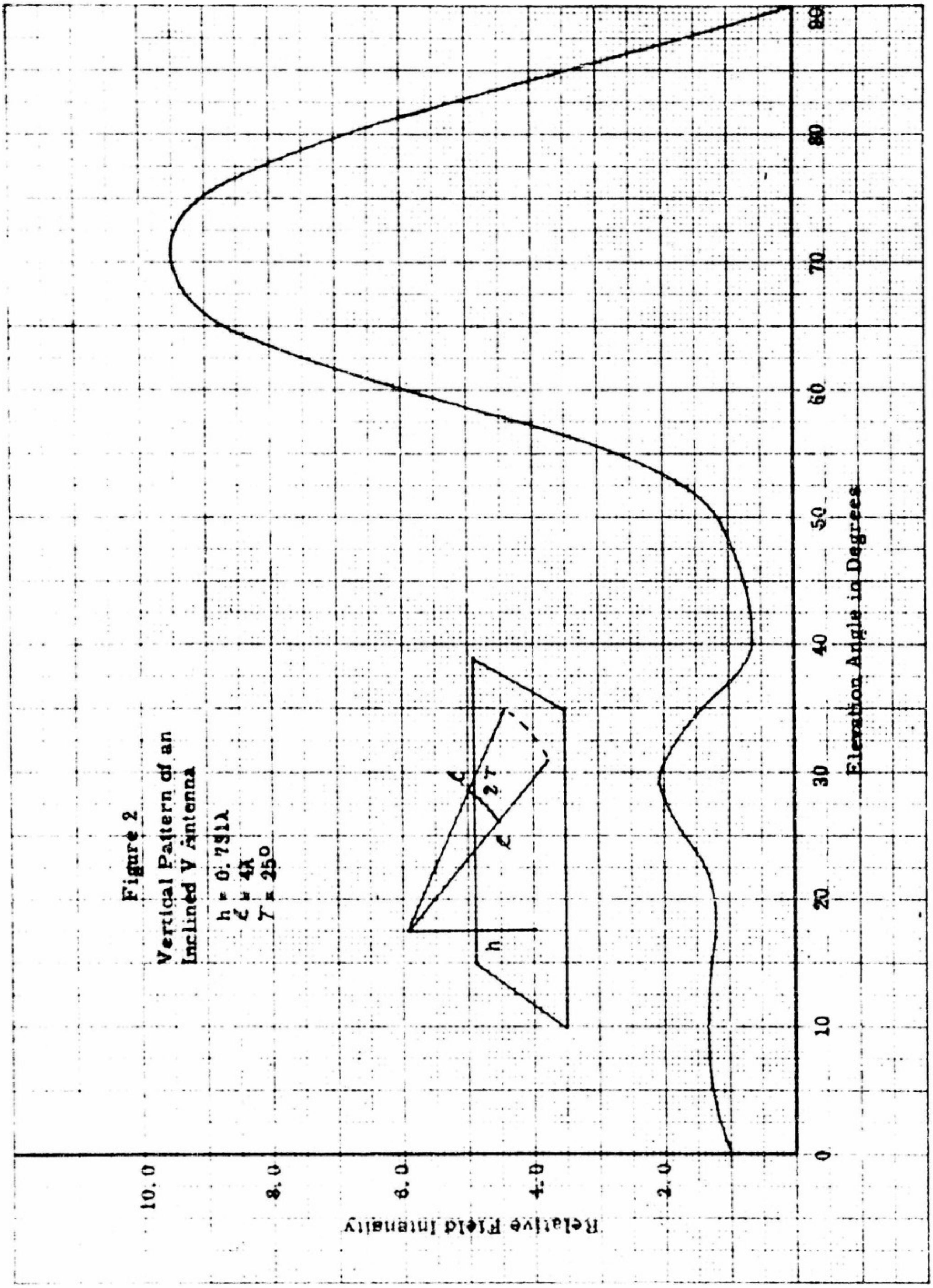


Figure 2

Vertical Pattern of an Inclined V Antenna

$h = 0.75\lambda$
$\ell = 4\lambda$
$\gamma = 25^{\circ}$

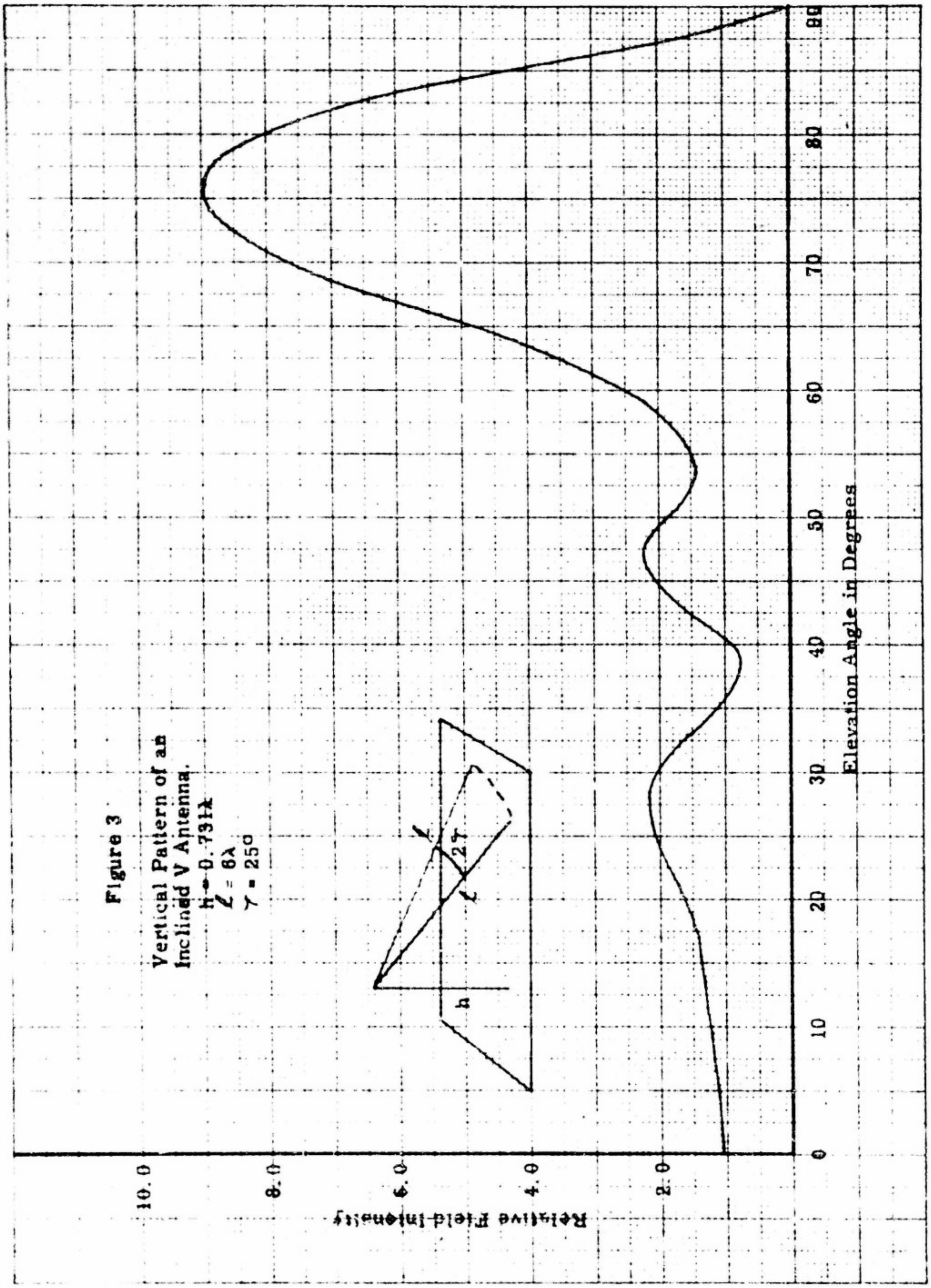


Figure 3
Vertical Pattern of an Inclined V Antenna.
h = 0.731λ
ℓ = 6λ
γ = 25°
h
ℓ
2γ
Relative Field Intensity
10.0
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80
90
Elevation Angle in Degrees

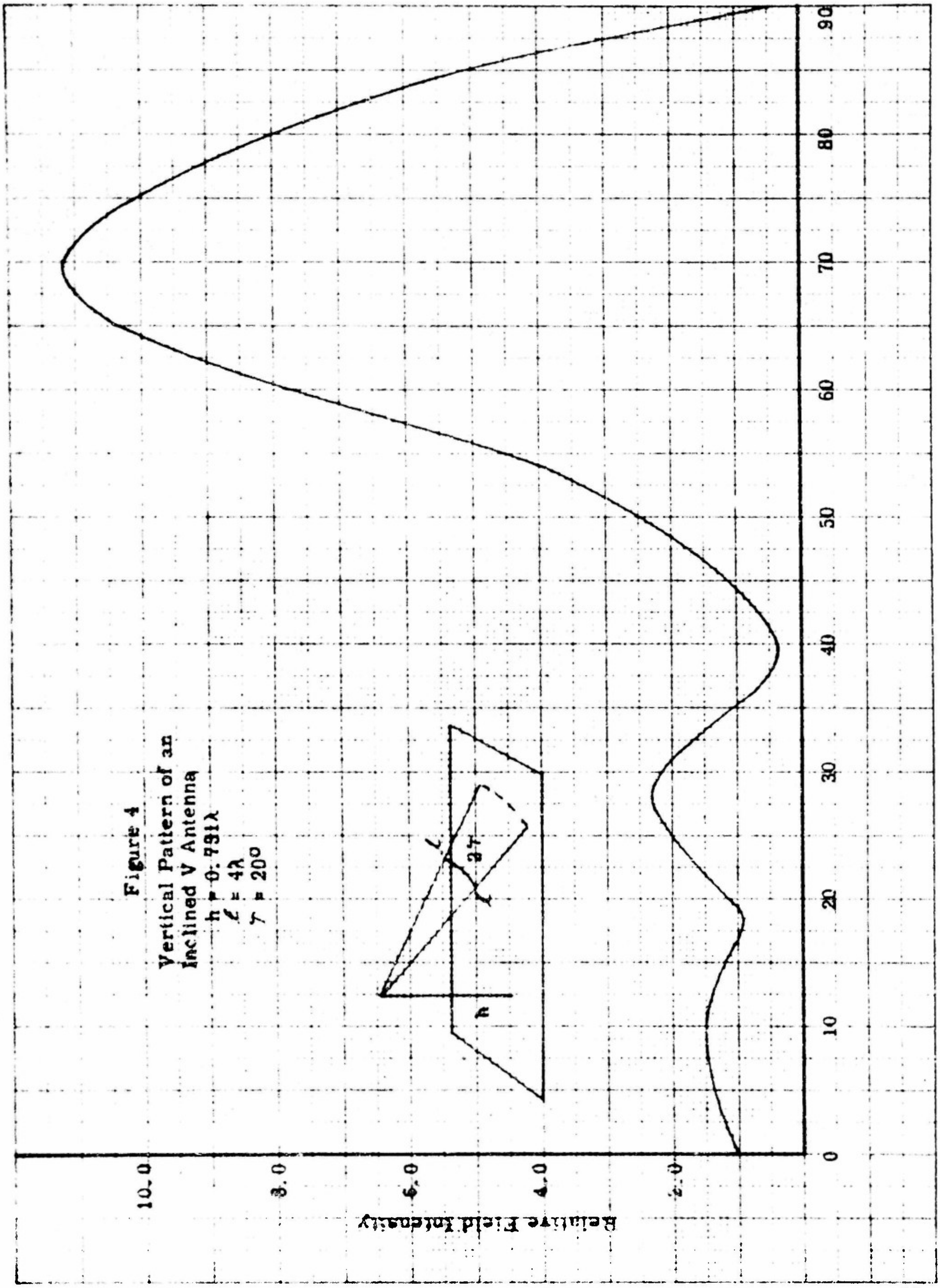


Figure 4

Vertical Pattern of an Inclined V Antenna

$h = 0.731\lambda$

$\ell = 4\lambda$

$\gamma = 20^\circ$

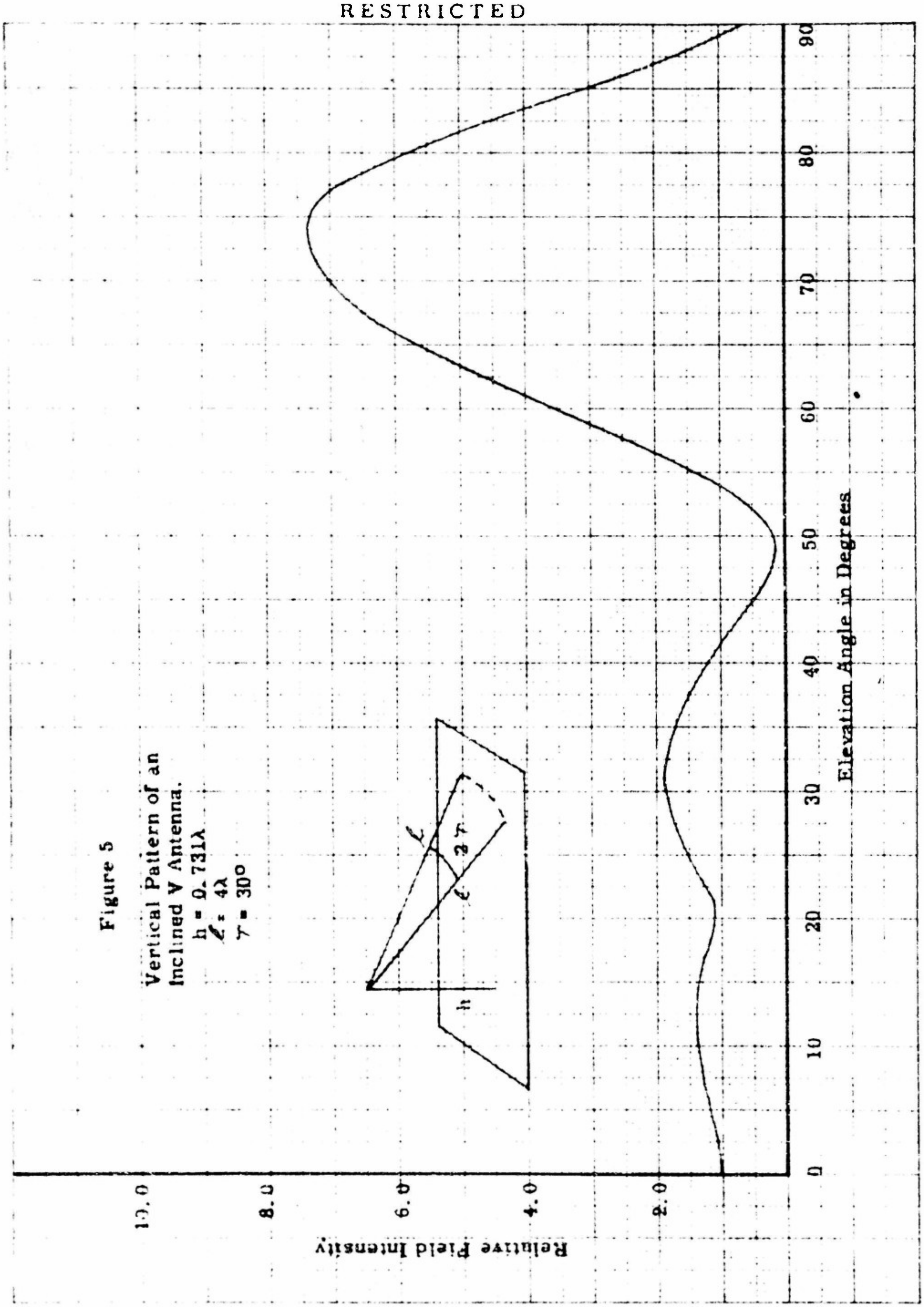


Figure 5
Vertical Pattern of an Inclined V Antenna.
h = 0.731λ
ℓ = 4λ
γ = 30°
h
ℓ
ℓ
2γ
Relative Field Intensity
10.0
8.0
6.0
4.0
2.0
0
10
20
30
40
50
60
70
80
90
Elevation Angle in Degrees

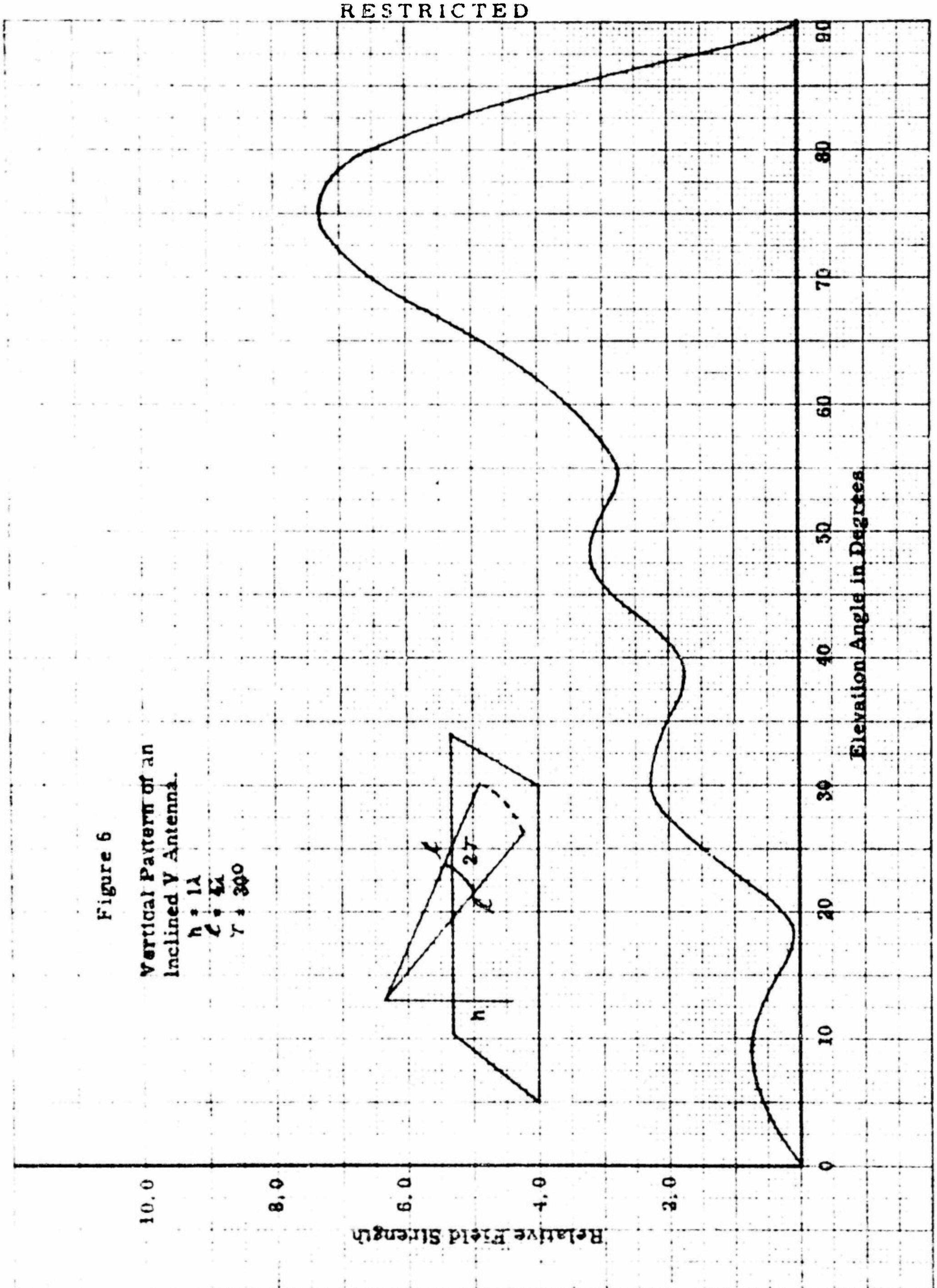


Figure 6

Vertical Pattern of an Inclined V Antenna.

$h = 1\lambda$
$\ell = 4\lambda$
$\gamma = 30°$

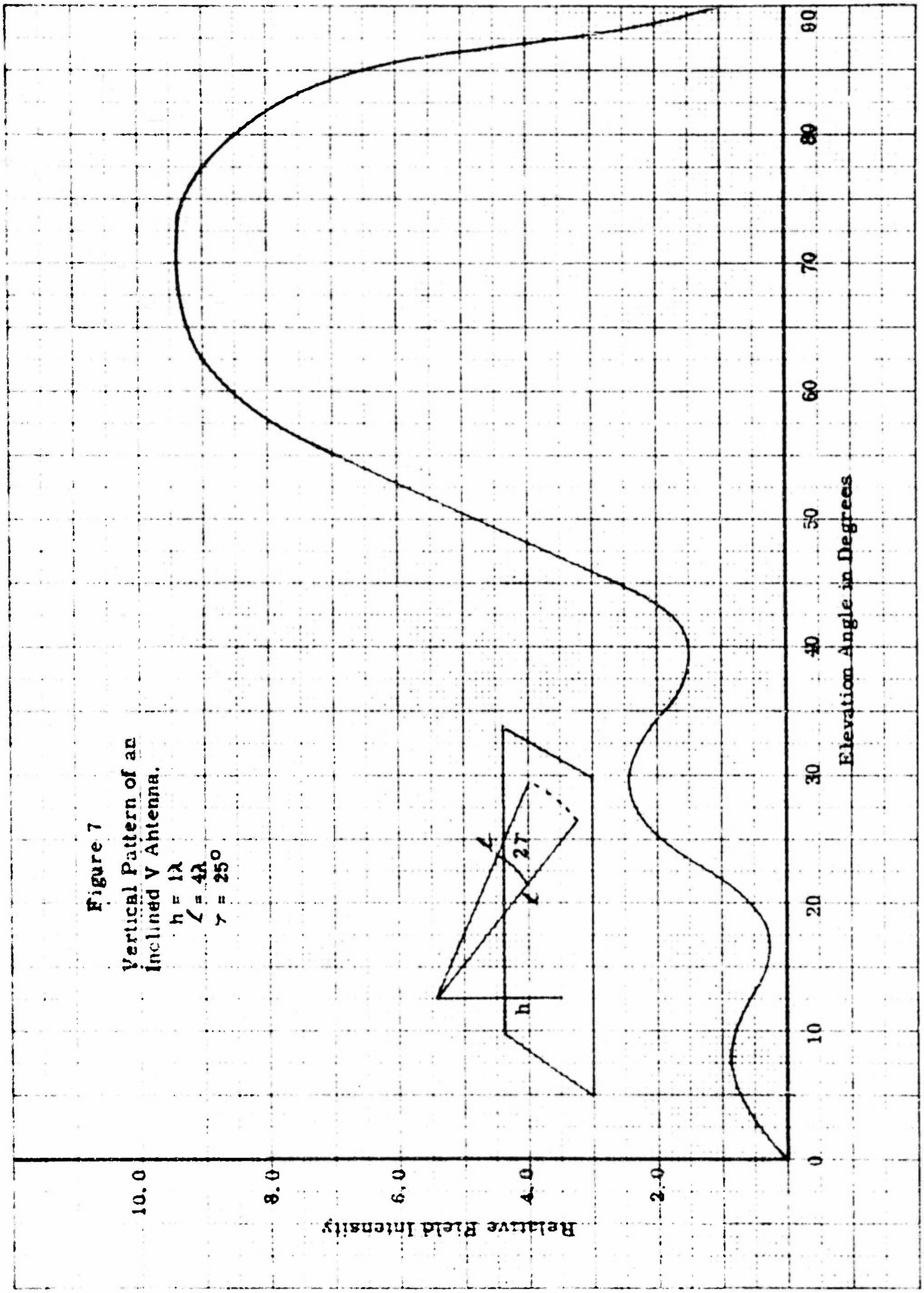


Figure 7
Vertical Pattern of an Inclined V Antenna.

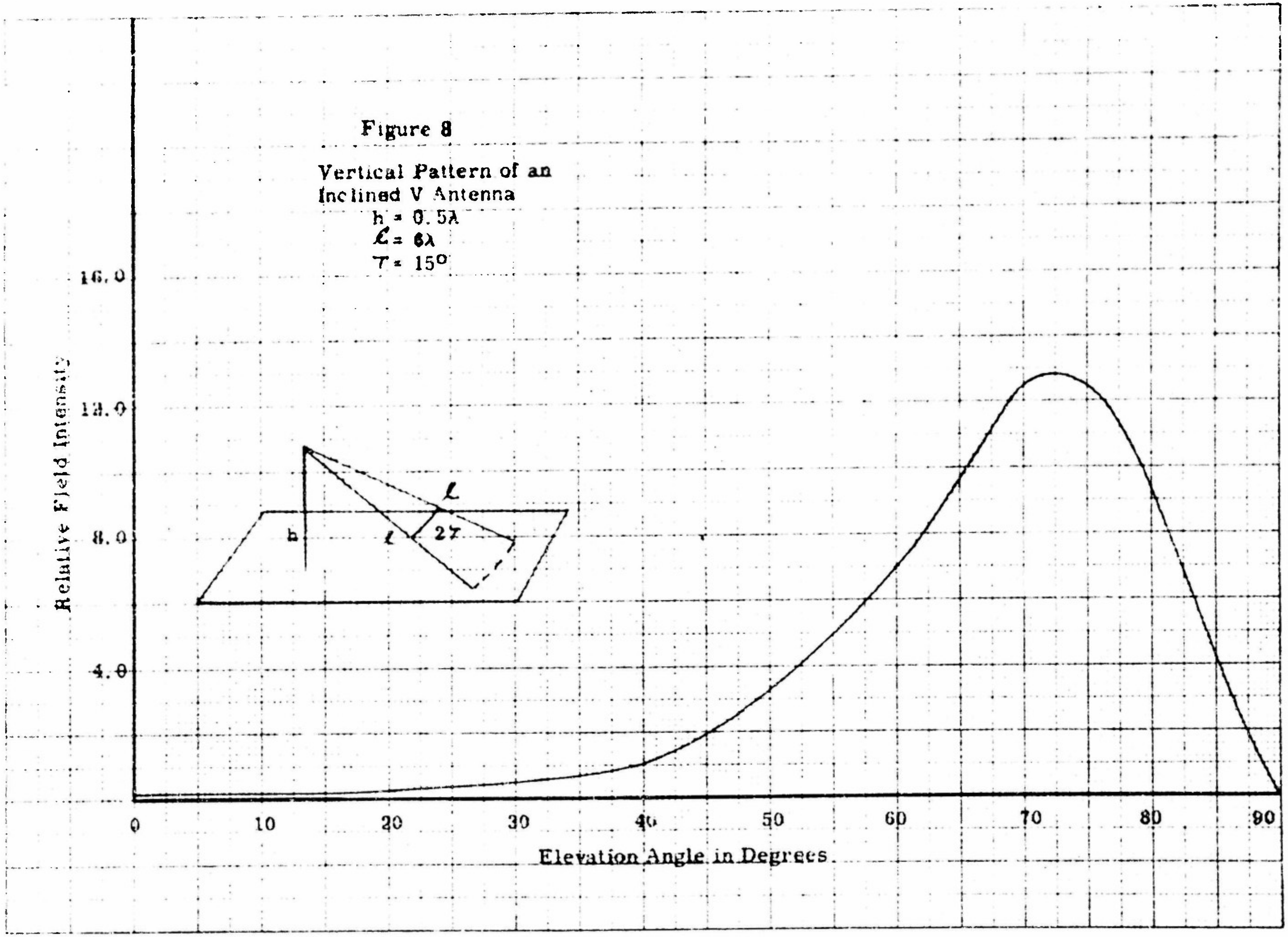


Figure 8

Vertical Pattern of an Inclined V Antenna

$h = 0.5\lambda$

$\mathcal{L} = 6\lambda$

$\Upsilon = 15^{\circ}$

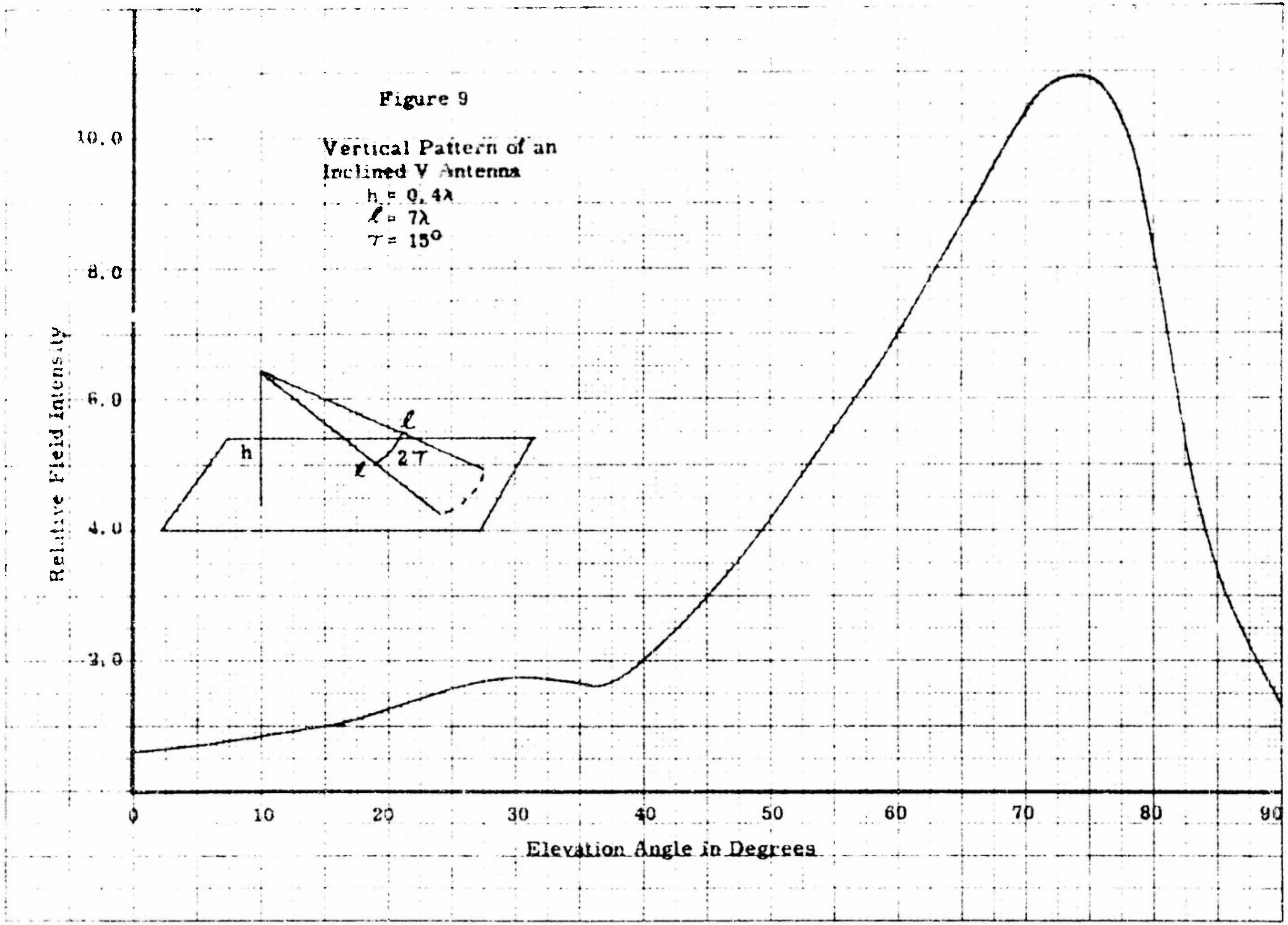


Figure 9

Vertical Pattern of an Inclined V Antenna

$h = 0.4\lambda$
$\ell = 7\lambda$
$\tau = 15^{\circ}$